MLS Scientific Publication

Scientific Themes: Upper tropospheric humidity, cloud ice, sea surface temperature, climate change

Relationships of upper tropospheric water vapor, clouds and SST: MLS observations, ECMWF analyses and GCM simulations

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Summary

In *Su et al.* (2006), observations of water vapor and cloud ice from the Microwave Limb Sounder on Aura satellite show that tropical upper tropospheric water vapor (UTWV) and cloud ice are positively correlated, and both quantities increase with increasing sea surface temperature (SST) when SST is greater than ~300 K. Over the convective regions, the rate of increase of UTWV with SST is 3 times larger than that for non-convective regions. This convective enhancement of the greenhouse effect by UTWV explains roughly 65% of the "Super Greenhouse Effect". In this study, the relationships of upper tropospheric water vapor (UTWV), cloud ice and SST are examined in the annual cycles of ECMWF analyses and simulations from 15 atmosphere-ocean coupled models which were contributed to the IPCC AR4. The results are compared with the observed relationships based on UTWV and cloud ice measurements from MLS on Aura. It is shown that the ECMWF analyses produce positive correlations between UTWV, cloud ice and SST, similar to the MLS data. The rate of the increase of cloud ice and UTWV with SST is about 30% larger than that for MLS. For the IPCC simulations, the relationships between UTWV, cloud ice and SST are qualitatively captured. However, the magnitudes of the simulated cloud ice show a considerable disagreement between models, by nearly a factor of 10. The amplitudes of the approximate linear relations between UTWV, cloud ice and SST vary by a factor up to 4.

The strong spatial correlations between UTWV, clouds and SST suggest that deep convection is a primary mechanism for creating the gradient of UTWV across the tropics. For climate models, accurate representation of these spatial relationships in annual cycle is a prerequisite to capture water vapor variations and its response to climate change. This model-data comparison work points to the large discrepancy of simulated cloud ice for climate models and thus improvement of cloud simulations is greatly needed.

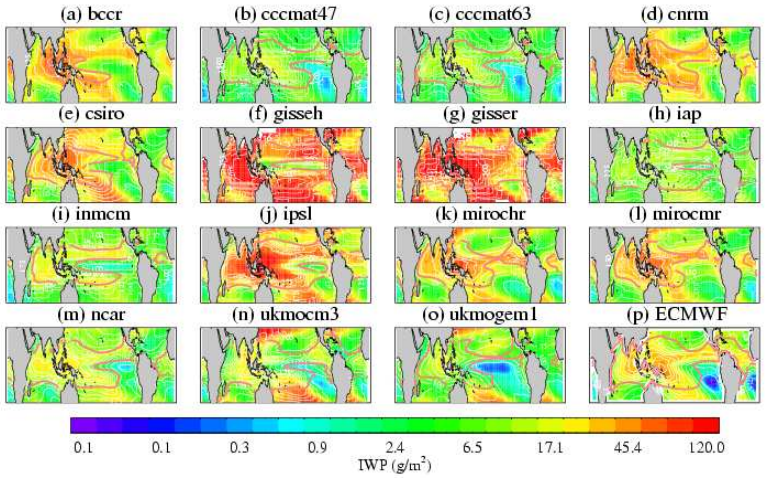

Figure 1: Maps of annual mean tropical (30°S-30°N) UTWV (in white contours), column-integrated IWP (shaded) and SST contour of 300 K (in orange) for the 15 IPCC models and ECMWF analyses. The UTWVs for all panels are contoured at the interval of 25 g m^{-2}.

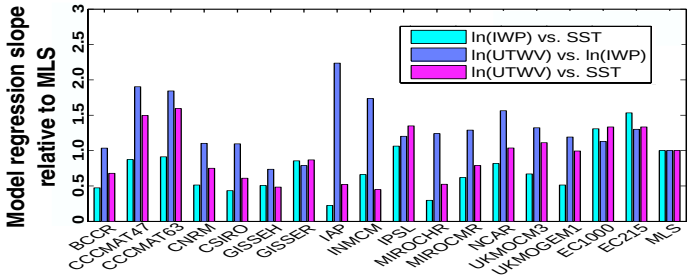

Figure 2: The ratio of the regression slopes of log(IWP)-SST, log(UTWV)-log(IWP), and log(UTWV)-SST relative to the MLS-observed for the IPCC models, ECMWF and MLS.